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(54) **Stable aqueous thrombin solution.**

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- (73) Proprietor: **GREEN CROSS CORPORATION**
15-1, Imabashi-1-chome
Higashi-ku
Osaka-shi
Osaka 541(JP)

(72) Inventor: **Nishimaki, Hideo**
412-4, Johonjicho
Kashihara-shi(JP)
Inventor: **Miyano, Kenmi**
2-24, Imazuminami-1-chome
Tsurumi-ku Osaka(JP)
Inventor: **Kameyama, Shouju**
7-306-303, Chokoyamas-asatani
Yawata-shi(JP)
Inventor: **Takechi, Kazuo**
25-308, Kawanakashinmachi
Daito-shi(JP)
Inventor: **Iga, Yoshiro**
11-13, Higashitokiwadal-6-chome
Toyoncho Toyono-gun Osaka(JP)

NEWBURN ELLIOTT
15, Abchurch Lane
London EC4A 1BO (GB)

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Description

This invention relates to a stable aqueous thrombin solution.

Thrombin acts on fibrinogen to form fibrin, thereby exerting a blood coagulating effect. For this reason, thrombin is used clinically as a hemostatic agent for topical application in the field of surgery.

Since thrombin is very unstable in its aqueous solution, it is usually made into a lyophilized medical preparation, which is used after being dissolved at the time of use.

However, liquid preparations are advantageous as compared with the lyophilized preparations in that they can be easily administered without being dissolved in distilled water or other solvents for injection.

From such a viewpoint, there have been proposed in recent years various methods for preparing a stable aqueous liquid composition of thrombin. For example, Japanese Patent Application Kokai (Laid-Open) No. 55-39,782 proposes a method comprising using an organic carboxylic acid, Japanese Patent Application Kokai (Laid-Open) No. 57-18,985 proposes a method comprising using albumin and Japanese Patent Application Kokai (Laid-Open) No. 62-106,028 proposes a method comprising using a buffer composition as a stabilizer, respectively.

GB-A-2081090 discloses a coagulant composition containing thrombin and stabilized by 30 vol% glycerol, an amino acid and polyethylene glycol.

However, these methods are still unsatisfactory and, up to the present, an aqueous liquid preparation of thrombin has not yet been put to practical use.

The object of this invention is to provide a stable aqueous thrombin solution.

The present inventors have made extensive studies to achieve the above-mentioned object and resultantly found that thrombin can be kept stable even in its aqueous solution by using a sugar and an amino acid in combination as a stabilizer. After further studies based on the above finding, the present invention has been accomplished.

Thus, according to this invention, there is provided a stable aqueous thrombin solution containing thrombin and, as stabilizer, a sugar and an amino acid, the sugar being present in an amount of from 2 to 10% (W/V) for a solution containing 50 to 5,000 units of thrombin per milliliter.

The thrombin to be used in this invention is not particularly limited so long as it has a biological activity or a physiological activity. Examples of suitable thrombin include those obtained by fractionation of plasma protein. Thus, there may be used thrombin prepared by making thromboplastin, snake venom etc. act in the presence of Ca^{2+} on prothrombin purified from human or bovine plasma. There may also be used a commercially available thrombin.

Thrombin to be used in this invention preferably has a specific activity in the neighborhood of 100 to 1,000 units/mg protein.

The concentration of thrombin in the thrombin-containing aqueous solution is preferably 50 to 5,000 units/ml, particularly preferably 100 to 3,000 units/ml.

The pH of the thrombin-containing aqueous solution is preferably 5 to 8, more preferably 6 to 7. To maintain such a pH, the use of buffer solutions is preferable. Examples of suitable buffer solutions include phosphate buffer solution and citrate buffer solution.

In this invention, a sugar and an amino acid are used in combination to heighten the stability of thrombin.

There is no particular restriction as to the sugar used as a stabilizer in this invention. Examples of suitable sugar are monosaccharides such as glucose and mannose; disaccharides such as maltose, sucrose and lactose; sugar alcohols such as sorbitol, mannitol and xylitol, which sugars may be used alone or in combination.

The quantity of sugar to be added is 2 to 10% (w/v), for a solution containing 50 to 5,000 units of thrombin per milliliter.

The symbol "%(w/v)" means herein a percentage of a solute by weight per volume of solution.

The amino acid to be used in this invention is not particularly limited. Preferred examples thereof

The quantity of the amino acid to be added is, for example, 0.1 to 5% (w/v), preferably 1 to 5% (w/v), for a solution containing 50 to 5,000 units of thrombin per milliliter.

The stable aqueous thrombin solution of this invention may also be incorporated with other conventional additives.

The stabilizer comprising a sugar in combination with an amino acid used in this invention significantly stabilizes thrombin.

In this invention, an aqueous solution containing thrombin and the stabilizers may be prepared so as to meet the requirements described above by using known techniques and then subjected to dialysis, sterile filtration, dispensation into vials, etc. according to conventional techniques of preparation. Thus, a stabilized aqueous solution (medical preparation) of thrombin is obtained.

According to this invention, there is provided a stable aqueous thrombin solution (medical preparation) which can keep its appearance and properties satisfactorily even after a long-term storage.

This invention will be further described in more detail below with reference to the following Examples and Experimental Example. However, this invention is in no way limited by these Examples.

Example 1

Prothrombin was purified from normal human plasma by means of barium chloride adsorption and DEAE-Sephadex® column chromatography [Bajaj, S.P. et al., J. Biol. Chem., 248, 7729(1973)]. The prothrombin obtained above was mixed with thromboplastin prepared from human placenta, human plasma and calcium chloride solution and subjected to thrombin conversion to give crude thrombin (thrombin activity per 1 mg protein: 10 units). The crude thrombin was purified by SP-Sephadex® column chromatography [Lundblad, R. L., Biochemistry, 10, 2501 (1971)]. The purified thrombin was concentrated and then dialyzed against a 100 mM citrate buffer solution (pH 7.0) containing 7.5% of D-mannitol by ultrafiltration system (PELLICON®) to obtain a thrombin solution (3,500 units/ml, thrombin activity per 1 mg protein: 500 units).

To 45 ml of the thrombin solution obtained above were added 65 g of sucrose and 27 g of arginine [final concentration: thrombin 1,500 units/ml, sucrose 65% (w/v), arginine 27% (w/v)] and the resulting solution was adjusted to pH 5.9 with sodium hydroxide. The solution was heat-treated at 60 °C for 20 hours and then dialyzed against 0.1M citrate buffer solution (pH 6.7) by ultrafiltration system (PELLICON®). The dialyzed solution was concentrated and filtered to obtain 105 ml of an aqueous thrombin solution [containing 1,100 units/ml of thrombin, 7% (w/v) of sucrose and 4.7% (w/v) of arginine; pH 6.7].

The aqueous thrombin solution was stored at 5 °C for one month. Then the appearance, thrombin activity, behavior in cellulose acetate membrane electrophoresis and gel filtration were examined. No marked change was observed in these test items, revealing that thrombin was stable in the test.

Example 2

Five thousand units of thrombin of official grade (Pharmacopeia of Japan) was dissolved in 10 ml of a phosphate buffer solution (pH 7). Then, sorbitol and glycine were added as a stabilizer to the resulting solution so that they have a concentration of 5% (w/v) and 1% (w/v), respectively, to obtain an aqueous thrombin solution.

This aqueous thrombin solution was also excellent in storage stability compared to that of Example 1.

Experimental Example 1

The aqueous thrombin solution obtained in Example 1 was used in order to examine the stability in a long-term storage. The aqueous thrombin solution was stored at 5 °C for one month. Comparisons were made under 4 different stabilizing conditions, namely, no addition, sugar alone, amino acid alone, and both in combination. Table 1 shows the results of the examination.

Table 1

	Stabilizer	Percentage residual thrombin (%)
	7% (w/v)	46
	4.6% (w/v)	95
Before storage		100

Claims

Claims for the following Contracting States : DE, GB, FR, BE, NL, SE, CH

- 5 1. A stable aqueous thrombin solution containing thrombin and, as stabilizer, a sugar and an amino acid the quantity of sugar being 2 to 10% (W/V) for a solution containing 50 to 5,000 units of thrombin per millileter.
2. A stable aqueous thrombin solution according to Claim 1 which has a pH of 5 to 8.
- 10 3. A stable aqueous thrombin solution according to Claim 1 or 2, wherein the quantity of amino acid is 1 to 10% (W/V) for a solution containing 50 to 5,000 units of thrombin per millileter.
4. A stable aqueous thrombin solution according to any preceding claim, wherein the sugar is at least one member selected from monosaccharides, disaccharides and sugar alcohols.
- 15 5. A stable aqueous thrombin solution according to any preceding claim, wherein the amino acid is at least one member selected from neutral amino acids, acidic amino acids and basic amino acids.

Claims for the following Contracting State : ES

- 20 1. A method for preparing a stable aqueous thrombin solution, in which, as stabilizer a sugar and an amino acid are added to an aqueous solution of thrombin, the sugar being added in an amount of 2 to 10% (w/v) for a solution containing 50 to 5,000 units of thrombin per millileter.
- 25 2. A method for preparing a stable aqueous thrombin solution according to Claim 1, wherein the thrombin solution has a pH of 5 to 8.
3. A method of preparing a stable aqueous thrombin solution according to Claim 1 or 2, wherein the quantity of amino acid is 1 to 10% (w/v) for a solution containing 50 to 5,000 units of thrombin per millileter.
- 30 4. A method for preparing a stable aqueous thrombin solution according to any preceding claim, wherein the sugar is at least one member selected from monosaccharides, disaccharides and sugar alcohols.
- 35 5. A method for preparing a stable aqueous thrombin solution according to any preceding claim, wherein the amino acid is at least one member selected from neutral amino acids, acidic amino acids and basic amino acids.

Patentansprüche

40 **Patentansprüche für folgende Vertragsstaaten : DE, GB, FR, BE, NL, SE, CH**

1. Stabile wäßrige Thrombinlösung, die Thrombin und als Stabilisator einen Zucker und eine Aminosäure enthält, wobei die Menge an Zucker 2 bis 10 % (Gew./Vol.) für eine 50 bis 5000 Einheiten Thrombin/ml enthaltende Lösung beträgt.
- 45 2. Stabile wäßrige Thrombinlösung nach Anspruch 1, die einen pH-Wert von 5 bis 8 aufweist.
3. Stabile wäßrige Thrombinlösung nach Anspruch 1 oder 2, wobei die Menge an der Aminosäure 1 bis 10 % (Gew./Vol.) für eine 50 bis 5000 Einheiten Thrombin/ml enthaltende Lösung beträgt.
- 55 4. Stabile wäßrige Thrombinlösung nach einem der vorangehenden Ansprüche, wobei die Aminosäure mindestens eine Aminosäure, ausgewählt aus neutralen Aminosäuren, sauren Aminosäuren und basischen Aminosäuren ist.

Patentansprüche für folgenden Vertragsstaat : ES

1. Verfahren zur Herstellung einer stabilen wäßrigen Thrombinlösung, in dem als Stabilisator ein Zucker und eine Aminosäure zu einer wäßrigen Lösung zugegeben werden, wobei der Zucker in einer Menge von 2 bis 10 % (Gew./Vol.) für eine 50 bis 5000 Einheiten Thrombin/ml enthaltende Lösung zugesetzt wird.
2. Verfahren zur Herstellung einer stabilen wäßrigen Thrombinlösung nach Anspruch 1, wobei die Thrombinlösung einen pH-Wert von 5 bis 8 aufweist.
3. Verfahren zur Herstellung einer stabilen wäßrigen Thrombinlösung nach Anspruch 1 oder 2, wobei die Menge an der Aminosäure 1 bis 10 % (Gew./Vol.) für eine 50 bis 5000 Einheiten Thrombin/ml enthaltende Lösung beträgt.
4. Verfahren zur Herstellung einer stabilen wäßrigen Thrombinlösung nach einem der vorangehenden Ansprüche, wobei der Zucker mindestens ein Zucker, ausgewählt aus Monosacchariden, Disacchariden und Zuckeralkoholen ist.
5. Verfahren zur Herstellung einer stabilen wäßrigen Thrombinlösung nach einem der vorangehenden Ansprüche, wobei die Aminosäure mindestens eine Aminosäure, ausgewählt aus neutralen Aminosäuren, sauren Aminosäuren und basischen Aminosäuren ist.

Revendications

Revendications pour les Etats contractants suivants : DE, GB, FR, BE, NL, SE, CH

1. Solution aqueuse stable de thrombine contenant de la thrombine et, comme stabilisateur, un sucre et un acide aminé, la quantité de sucre étant de 2 à 10% (p/v) pour une solution contenant de 50 à 5 000 unités de thrombine par millilitre.
2. Solution aqueuse stable de thrombine selon la revendication 1, qui a un pH de 5 à 8.
3. Solution aqueuse stable de thrombine selon les revendications 1 ou 2, dans laquelle la quantité d'acide aminé est de 1 à 10% (p/v) pour une solution contenant de 50 à 5 000 unités de thrombine par millilitre.
4. Solution aqueuse stable de thrombine selon l'une quelconque des revendications précédentes, dans laquelle le sucre est au moins un membre choisi parmi les monosaccharides, les disaccharides et les alcools sucrés.
5. Solution aqueuse stable de thrombine selon l'une quelconque des revendications précédentes, dans laquelle l'acide aminé est au moins un membre choisi parmi les acides aminés neutres, les acides aminés acides et les acides aminés basiques.

Revendications pour l'Etat contractant suivant : ES

1. Procedé de preparación de una solución acuosa estable de trombina segun la reivindicación 1, en el que la solución de trombina a un pH de 5 a 8.
2. Procedé de preparación de una solución acuosa estable de trombina segun la reivindicación 1, en el que la solución de trombina a un pH de 5 a 8.

Revised text for the Spanish claims, ensuring accuracy and readability while maintaining the original meaning and structure where possible.

EP 0 302 754 B1

4. Procédé de préparation d'une solution aqueuse stable de thrombine selon l'une quelconque des revendications précédentes, dans lequel le sucre est au moins un membre choisi parmi les monosaccharides, les disaccharides et les alcools sucrés.
5. Procédé de préparation d'une solution aqueuse stable de thrombine selon l'une quelconque des revendications précédentes, dans lequel l'acide aminé est au moins un membre choisi parmi les acides aminés neutres, les acides aminés acides et les acides aminés basiques.

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